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Full Length Research Paper

Nutritional evaluation of treated canola straw for ruminants using *in vitro* gas production technique

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The aim of the present study was to determine the chemical composition and estimate the nutritive value of molasses treated with canola straw using *in vitro* gas production technique with Taleshi native male cattle. Experimental materials were collected from different regions of Parsabad province (Ardabile, Iran). Experimental group were: untreated canola straw (control) and 4% molasses treated canola straw. After providing uniform mix, chemical composition for untreated straw including dry matter (DM), crude protein (CP), ether extract (EE), crude ash (CA), neutral detergent fiber (NDF), acid detergent fiber (ADF) and nonfibrous carbohydrates (NFC) were estimated: 89.66, 2.8, 3.9, 2.4, 79.2, 58.8 and 11.7%, respectively and for molasses treated straw, they were: 66.21, 3.12, 3.9, 3.57, 77.2 57.4 and 12.21%, respectively. Gas production test with mixtures of filtered rumen liquid of two Taleshi native male cattle rumen in time periods of 2, 4, 6, 8, 12, 24, 48, 72 and 96 h was performed. The results show that organic matter digestibility (OMD) and metabolizable energy (ME) for treated canola straw were significantly higher than that of untreated canola straw (control) (p<0.001). Gas productions at 24 h for untreated canola straw (control) and treated canola straw were 20.03 and 27.07 ml, respectively. Overall, it seems that the nutritive value of treated canola straw was higher than that of untreated canola straw (control) for ruminants.

Key words: Nutritive value, canola straw, metabolizable energy, gas production technique.

INTRODUCTION

In tropical zones in the world, ruminants depend on year-round grazing on natural pastures or are fed with cut grass and crop residues. Most of these areas face seasonal dry periods in which the availability of pasture decreases and also, there is a reduction in quality in terms of digestible energy and nitrogen content. Because in this area, straw is abundantly available from cultivating, farmers offer straw as the main roughage source to their animals. This is particularly the case in Southeast Asian countries such as Thailand, Vietnam and Indonesia. Feeding on only straw does not provide enough nutrients to the ruminants to maintain high production levels due to the low nutritive value of this highly lignified material. The high level of lignification and silicification, the slow and limited ruminal degradation of the carbohydrates and the low content of nitrogen are the main deficiencies of straw, affecting its value as feed for ruminants (Van Soest, 2006). As straw is poorly fermented, it has low rates of disappearance in the rumen and low rates of passage through the rumen, reducing feed intake (Conrad, 1996). By treating straw with urea or calcium hydroxide or by supplementing straw with protein, intake, degradability and milk yield can be enhanced, as compared to feeding with untreated straw alone (Fadel Elseed, 2005; Wanapat et al., 2009). According to the canola straw, chemical composition was comparable between wheat and barley straw. The objective of this study was to determine the nutritional value of canola straw treated with molasses using *in vitro* gas production technique.

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MATERIALS AND METHODS

Samples and treatments

Straw samples were obtained from commercial sources of Parsabad region of Iran with sufficient water with 4% molasses been added to straw and kept until 45 days in the anaerobic

Table 1. The chemical composition of untreated and treated canola straw (%).

Treatment	Dry matter	Crude protein	Ash	Ether extract	Neutral detergent fiber	Acid detergent fiber	Nonfibrous carbohydrates
Control	89.86	2.80	2.40	3.90	79.2	58.8	11.7
4% Molasses	66.21	3.90	3.57	3.90	77.2	57.4	12.21

condition. For determination of nutritional evaluation of untreated and treated canola straw in gas test syringes, all samples were then ground in a laboratory mill through a 1 mm screen.

Chemical analysis

Dry matter (DM) was determined by drying the samples at 105°C overnight and ash by igniting the samples in a muffle furnace at 550°C for 6 h. Nitrogen (N) content was measured using the Kjeldahl method (AOAC, 1990). Crude protein was calculated as N × 6.25. Acid detergent fiber ADF content and neutral detergent fiber NDF content of leaves were determined using the method described by Van Soest et al. (1991). Non-fibrous carbohydrate (NFC) was calculated using the equation of NRC (2001):

NFC = 100 – NDF + CP + EE + Ash

All chemical analyses were carried out in triplicate.

In vitro gas production

Rumen fluid was obtained from two fistulated cattle fed twice daily with a diet containing alfalfa hay (60%) and concentrate (40%). The samples were incubated in the rumen fluid in calibrated glass syringes following the procedures of Menke and Steingass (1988) as follows: 0.200 g dry weight of the sample was weighed in triplicate into calibrated glass syringes of 100 ml. The syringes were pre-warmed at 39°C before injecting 30 ml rumen fluid-buffer mixture into each syringe followed by incubation in a water bath at 39°C. The syringes were gently shaken 30 min after the start of incubation and every one hour for the first 10 h of incubation. Gas production was measured as the volume of gas in the calibrated syringes and was recorded before incubation and 2, 4, 6, 8, 12, 24, 48, 72 and 96 h after incubation. Total gas values were corrected for blank incubation, which contained only rumen fluid. Cumulative gas production data were fitted to the model of Ørskov and McDonald (1979):

Y= a + b (1-exp-ct)

Where, a is the gas production from the immediately soluble fraction (ml); b is the gas production from the insoluble fraction (ml); c is the gas production rate constant for the insoluble fraction (b); t is the incubation time (h) and y is the gas produced at the time 't';
The metabolizable energy (MJ/kg DM) content of feeds and short chain fatty acid (SCFA) was calculated using equations of McDonald et al. (1995), Menke and Steingass (1988), Menke et al. (1979) and Maheri-sis et al., (2008):
For all feeds,

ME (MJ/kg DM) = 0.016 DOMD
for forage feeds,
ME MJ/kg DM= 2.20 + 0.136 GP + 0.057 CP +0.0029 CF2
For concentrate feeds,
ME MJ/kg DM = 1.06 + 0.157 GP + 0.084 CP +0.22 CF - 0.081 CA

Where, GP is the 24 h net gas production (ml/200 mg^{-1}) and CP is the crude protein

The SCFA for all feeds was calculated using equations of Menke et al. (1979) as follows:

SCFA m mol/200 mg DM = 0.0222 GP - 0.00425

The OMD was calculated using equations of Menke et al. (1979) as follows:

OMD (%) = 14.88 + 0.889 GP + 0.45 CP + XA

Where, GP is the about 24 h net gas production (ml / 200 mg^{-1}); CP and crude protein (%) and XA is the ash content (%).

Statistical analysis

Data on apparent gas production parameters were subjected to one-way analysis of variance using the analysis of the variation model ANOVA of SAS (2000). Multiple comparison tests were done using Duncan's multiple-t-test (1980). Mean differences were considered significant at $P<0.05$. Standard errors of means were calculated from the residual mean square in the analysis of variance. All data were obtained from three replicates.

RESULTS AND DISCUSSION

Metabolizable energy (ME) and short chain fatty acid (SCFA)

According to studies (Menke and Steingass, 1988; Menke at al., 1979; McDonald et al., 1995), SCFA and ME could be evaluated by 24 h *in vitro* gas production data and *in vivo* organic matter digestibility. These results are shown in Table 4.

Chemical composition

The chemical composition of untreated and treated canola straws are shown in Table 1. Chemical composition, including the dry matters, crude protein, ether extract, crude ash, neutral detergent fiber, acid detergent fiber and nonfibrous carbohydrates were estimated to be 89.66, 2.8, 3.9, 2.4, 79.2, 58.8 and 11.7%, respectively and for molasses treated straw, they were: 66.21, 3.12, 3.9, 3.57, 77.2 57.4 and 12.21%, respectively.

In vitro gas production

Gas production volumes (ml/200mg DM) at different

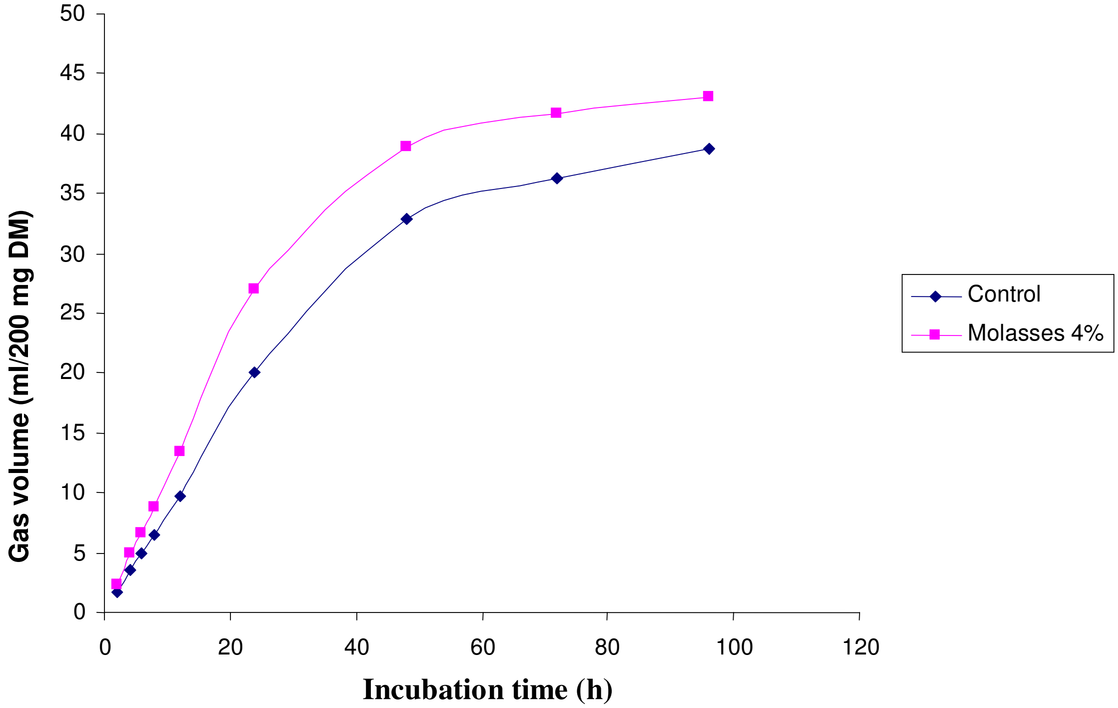

Figure 1. Gas production volumes at different incubation times.

Table 2. *In vitro* gas production volumes (ml/200 mg DM) of untreated and treated canola straw at different incubation times.

Treatment	Incubation time								
	2	4	6	8	12	24	48	72	96
Control	1.65	3.56	4.87	6.44	9.75	20.03	32.93	36.24	38.68
4% Molasses	2.27	4.90	6.70	8.86	13.41	27.07	38.82	41.68	43.13
P value	0.0352	0.0046	0/0008	0/0002	P<0.0001	0.0006	0.0140	0.0327	0.0485
SEM	0.150	0.212	0.283	0.372	0.540	1.072	0.988	0.955	0.864

Table 3. The estimated parameters for the gas production of untreated and treated canola straw.

Treatment	Estimated parameter			
	a	b	|a+b|	c
Control	1.86	43.80	45.66	0.029
4% Molasses	2.49	47.49	49.98	0.038
P value	0.0023	0.1879	0.1007	0.0003
SEM	0.126	0.866	0.928	0.0013

a: The gas production from soluble fraction (ml/200 mg DM), b: the gas production from insoluble fraction (ml/200 mg DM), c: rate constant of gas production during incubation (ml/h), (a+ b): the potential gas production (ml/200 mgDM).

incubation times are shown in Figure 1. The gas production kinetics, are given in Table 2. There are considerable increases in gas production when the canola straw was incubated with the addition of molasses. The soluble fraction (a) and insoluble but fermentable fraction (b), for untreated canola straw and treated canola straw treatments were 1.86, 43.80, and 2.49, 47.49 ml, respectively. The untreated canola straw decreased the gas production of the insoluble, fermentable fraction (b), potential gas production (a+b) and increased gas production in terms of gas production rate (c). Whereas, treated canola straw had significant effect on the gas production in the immediate soluble fraction (a), also, there were significant increases in the OMD and ME content in treated canola straw with the addition of molasses (Table 3).

Table 4. Short chain fatty acid (MOL) organic matter digestibility (%), and metabolizable energy (MJ/KG DM) of untreated and treated canola straw.

Treatment	SCFA	OMD	ME
Control	0.4406	35.41	5.15
4% Molasses	0.5963	42.99	6.17
P value	0.0027	P<0.0001	P<0.0001
SEM	0.0364	1.321	0.186

SCFA = Short chain fatty acid, OMD = organic matter digestibility, ME =metabolizable energy and S.E.M = standard error of the mean.

Conclusion

According to the results, it can be stated that treating canola straw with molasses increased rumen organic matter digestibility and metabolizable energy and therefore, could be used in the ruminant diet.

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